a capital sum of two thousand billion dollars.[2] A great part of this advance is due to a few men, probably one half of it to, at most, 10,000 men. The value of each of these men to the world has been a hundred million dollars; they have been men not abler nor more productive on the average than the upper five hundred of our leading American men of science.

So far from being exaggerated this valuation of science and of scientific men neglects the decrease of disease and suffering, the increased length of life and the vast number of human beings for whom life has been made possible. It can not take account of the moral, intellectual, political and social changes wrought by science and its applications. Science has made democracy possible and has given us as much of it as we have. The applications of science have abolished the necessity of continuous manual labor from childhood to old age, they have made feasible universal education, equality of opportunity and equality of privilege, they have banished legal slavery, they have partly done away with the labor of children and the subjection of women. Science has given us freedom in the moral as well as in the material world, freedom from ignorance, superstition and unreason, the means of learning the truth and the right to tell it.

The service of science for the world is by no means complete. The productivity of labor can be again doubled by further scientific discovery; it can be more than doubled by the selection of the right men for the work they do and by correct methods of work. The value of wealth can be doubled by its proper distribution and use. Warfare, preventable disease and vice, waste and display, the futile complications of civilization, consume one half of all the wealth that is produced. We do not know the conditions of happiness and real welfare or how they are to be attained. Science should continue to press to the limit economy of production and the conservation of health and life; at the same time it should increasingly direct its methods to the control of human conduct.

[2] This enormous figure is based on the assumption that there are 25,000,000 people in the United States, whose productive work is worth on the average $1,000 a year and six times as many in the civilized world who earn on the average half so much, with enough left over to balance the earnings of 100 years ago.

Suddenly, out of its stale and drowsy lair, the lair of slaves,
Like lightning it leapt forth half startled at itself,
Its feet upon the ashes and the rags, its hands tight to the throats of kings.

On us here in America there has been thrust the duty and the privilege to carry forward the flickering torch of science and of civilization. Our society of the Sigma Xi and each of us have indeed great opportunity and great responsibility.

J. McKeen Cattell

RADIUM FERTILIZER IN FIELD TESTS

With the discovery of radio-activity by Becquerel, in 1896, and of radium itself by M. and Mme. Curie, in 1898, science revealed a property of matter and a source of energy hitherto unknown; and the facts already established, the predictions or claims made, and the general interest in the subject seemed to justify an investigation under field conditions of the possible value of radium as a fertilizer, or of radio-activity as a crop stimulant.

While possessing most of the properties of an element, reacting chemically very similarly to the element barium, radium also has the remarkable property of continuous disintegration, by continuous emanation of particles, which is accompanied by radiation of energy, called radio-activity.

Investigations show that one gram of radium emits enough heat to raise 118 grams of water one degree centigrade in one hour, or 118 calories, and indicate about enough total energy to decompose one gram of water into hydrogen and oxygen every twenty-four hours, equivalent to more than 3,800 calories, or nearly 160 calories per hour. This radiation continues hour after hour with gradual reduction to $\frac{1}{2}$ the quantity in about 1,760 years, to $\frac{1}{4}$ in

3,520 years, to $\frac{1}{8}$ in 5,280 years, and so on. Thus the total energy ultimately evolved from 1 pound of radium is equivalent to more than 70,000 twenty-four-hour days of horse-power.

Many experiments have been made to ascertain the effect of radio-activity on plant growth; and in general a distinct influence is noted, although some experimenters report negative results.

Gager[1] in summarizing his investigations states that radium acts under certain conditions as a stimulus to physiological processes, but, if used in too great strength or for too long a period, it may retard development or even kill the plant.

Fabre[2] noted some beneficial effects from emanations, using a concentration of $1\frac{1}{2}$ microcuries[3] for each 2 liters of air, but injury from greater strength.

Stoklasa[4] found that radium emanations promoted germination of seeds and accelerated the growth of plants to a considerable extent. From earlier experiments he has reported increased fixation of nitrogen by bacteria.

In the spring of 1913, through the kindness of the Standard Chemical Company of Pittsburgh the University of Illinois Agricultural Experiment Station was enabled to begin a series of field experiments with radium as a fertilizer or crop stimulant. The company was deeply interested in having the experiments conducted, and the radium salts furnished to us were prepared under the direction of Doctor Otto Brill and Doctor Charles H. Viol, of the radium research laboratory of the Standard Chemical Company, the quality and strength of the preparations being thus assured.

The value of radium is about $100 per milligram and in order that the field investigation might have a direct relation to practical agriculture, the radium was used at three rates of application, costing, respectively, $1, $10 and $100 per acre; or in amounts of .01 milligram, .1 milligram and 1 milligram of radium per acre. If the effect of the application should be marked and permanent, even the initial expense of $100 per acre might be desirable.

The fields selected for these experiments were the north division of Series 200 and the south division of Series 600 of the agronomy plots on the South Farm of the University of Illinois. Each of these fields includes 144 fortieth-acre plots, two rods square, besides some divisions and border strips, making the field sixteen rods wide east and west, and thirty-eight rods long north and south.

On Series 200 and on the west part of Series 600, the radium was applied in a solution of radium barium chloride diluted with distilled water, the check plots receiving the same quantity of distilled water without radium. On the east part of Series 600 solid radium barium sulfates were applied, after diluting by thoroughly mixing and pulverizing with dry soil from the field, the check plot receiving the same weight of soil without radium. The pulverized soil was applied with a force-feed grain drill, and the solutions with an Aspinwall barrel sprayer.

The amount of radio-active substances applied in these tests was purposely made small, in order to avoid any appreciable effect of the substance other than that due to radio-activity. It is conceivable that some effect might be obtained from the application of 100 or 200 pounds per acre of mineral salts. The amount in the case of the heaviest applications was less than five pound of total salts per acre.

On both fields corn was grown in 1913 and soy beans in 1914. Owing to other experimental work involving some variations in planting, only part of Series 600 furnished comparable data in 1913, only twenty-four separate trials being provided. The work of the two years,[5] however, comprised 144 tests with corn and 240 tests with soy beans. Aside

[1] *Popular Science Monthly*, Vol. 74, pp. 222–32.

[2] *Compt. Rend. Soc. Biol.*, 70, 187, 419.

[3] A microcurie is a millionth part of a curie, the unit of measurement for radio-activity, which is the quantity of radium emanation in equilibrium with one gram of radium. In other words, the curie represents the constant or continuous energy of one gram of radium.

[4] *Chemiker Zeitung*, Vol. 38 (1914), No. 79, pp. 841–44.

[5] For detailed data see Bulletin No. 177, University of Illinois Agricultural Experiment Station.

from the corn grown on Series 200 in 1913, the average results are considered trustworthy.

EFFECT OF RADIUM ON FIELD CROPS
Increase or Decrease per Acre

Radium per Acre, Mgs.....		.01		.1		1	
Crops Grown		Gain	Loss	Gain	Loss	Gain	Loss
Corn, ser. 200, 1913, bushels	West	—	1.0	2.6	—	3.9	—
	East	2.3	—	3.0	—	3.5	—
Corn, ser. 600, 1913, bushels	West	.1	—	.8	—	1.7	—
	East	—	.3	—	1.2	—	.6
Soy beans, ser. 200, 1914, bushels	West	—	.5	1.0	—	—	.2
	East	1.4	—	1.9	—	1.1	—
Soy beans, n. half of ser. 600, 1914, bushels	West	—	.2	—	1.1	—	1.5
	East	1.0	—	.5	—	2.2	—
Soy-bean hay, s. half of ser. 600, 1914, lbs.	West	275	—	—	138	—	215
	East	—	13	—	74	42	—

Series 600 possesses an unusually satisfactory degree of uniformity; but on Series 200 there are some topographic variations which influence the rapidity of "run-off" or absorption of rain, and in very dry seasons, with occasional dashing showers, when moisture is a factor of great importance, these variations appear in the crop yields. From April 11 to September 11, a period of five months, the total rainfall in 1913 was only 5.87 inches. Under these adverse conditions, even the average results from Series 200 are not considered trustworthy, notwithstanding the large number of separate trials making the averages. Even from the general averages .01 milligram of radium appears to have decreased the yield by 1 bushel on the west part and to have made 2.3 bushels increase on the east part of the field. Again, increasing the cost of radium from $1 to $10 per acre appears to have increased the yield of corn by 3.6 bushels on the west part and by only .7 bushel on the east part; and the further increase of $90 shows apparent gains of 1.3 bushels on the west and .5 bushel on the east part of this field. Of course no conclusions should be drawn from such discordant plus and minus results.

The results with soy beans on Series 200 in 1914 agree within narrow limits in showing no benefit from the radium applied the year before, the west half of the field giving slightly smaller and the east half slightly larger average yield where radium was added than on the check plots.

On Series 600 the average yields of corn in 1913 were slightly larger with two kernels per hill and slightly smaller with three kernels per hill where radium was applied, but the apparent gains and losses are all well within the experimental error of plot variation, and the general average indicates no effect from the radium. The yields of soy-bean seed on the north half of this field in 1914 likewise reveal no influence of radium, all rates of application indicating as an average slight decreases for radium on the west side and slight increases on the east side of the field. With the soy-bean hay the six general averages show no effect from radium, four results being slightly below the checks and the other two slightly above.

Thus from the two years' work we have six trustworthy average results with corn, three "for" and three "against" radium, and we have eighteen averages with soy beans, nine "for" and nine "against" radium. In all of these trials the average variation from the checks is so slight and so evenly distributed, "for" and "against," as to lead only to the conclusion that radium applied at a cost of $1, $10 or $100 per acre has produced no effect upon the crop yields either the first or second season.

Radium, with all its wonderful energy, is found upon careful analysis of the known facts, to afford no foundation for reasonable expectation of increased crop yields, when financial possibilities are considered. The rate of application mentioned by Fabre, on the basis of 1½ microcuries for each space four inches square and eight inches high, would cost about $58,800 per acre at present prices for radium.

It is true that the total ultimate energy developed in 1,760 years from 1 pound of radium will be equivalent to 35,000 horse-power days of 24 hours each; but when the time is reduced to 100 days of good crop-growing weather, and the amount of radium reduced to 10 milligrams, or to a cost of $1,000 per acre, then the energy emitted from the radium

for the possible benefit of an acre of corn during the crop season would be equivalent to 1 horse-power for 22 seconds; and the heat evolved by $1,000 worth of radium on an acre of land in 100 days would be less than the heat received from the sun on one square foot in 30 seconds.

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SPECIAL ARTICLES

NEW REPTILES FROM THE TRIAS OF ARIZONA AND NEW MEXICO

BEGINNING the later part of March, 1914, the University of Wisconsin paleontological expedition spent two months in Arizona and New Mexico collecting Triassic vertebrates. The time was divided chiefly between two localities, Wingate, New Mexico, nine miles east of Gallup, and along the Little Colorado River some fifty miles northeast of Flagstaff, Arizona. In both localities material was collected which should add substantially to our knowledge of the Triassic vertebrate faunas of the west.

Conspicuous among the collections are Phytosaur remains of various types. One nearly complete skull, apparently the largest yet discovered, will probably prove to be a new form.

One of the most interesting finds from the Wingate region is that of a nearly complete pelvic girdle of distinctive form. The sacrum consists of two closely united vertebræ with moderately biconcave centra. The neural arches are massive and are surmounted by stout, comparatively short spines with considerably expanded tops. The sacral ribs unite broadly with the arch and centrum, each rib being supported by a single vertebra. Distally the ribs are greatly expanded in an antero-posterior direction and are considerably thickened below and apparently down curved along the inner side of the ilium.

The upper portion of the ilium is expanded both laterally and in an antero-posterior direction into a broad, horizontal shelf. The ischia meet along the median line in a trough-like union that extends back in a horizontal tongue-shaped process. The pubes take a comparatively small part in the floor of the pelvic opening as the lower anterior portion of these elements extends directly down in a broad plate-like expansion at right angles to the vertebral column. The lower outer corner of the pubic expansion is swollen into a foot-like process, possibly to bear a portion of the weight of the creature when at rest.

All three elements enter the imperforate acetabulum in a firm union. The acetabulum is large and deeply concave and set off by a prominent raised boundary. It is directed out and down and considerably back. The girdle measures about 450 mm. from the top of the sacral spines to the lower border of the plate-like expansion of the pubis. The greatest width, at the lateral expansion of the upper portion of the ilia, is approximately 370 mm.

The massive construction of the girdle has suggested the name *Acompsosaurus wingatensis* for this new form. It is to be hoped that other material in the collections will add a knowledge of other parts of the skeleton. Figures and a more complete description of *Acompsosaurus wingatensis* will follow in another place.

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SOCIETIES AND ACADEMIES

THE BIOLOGICAL SOCIETY OF WASHINGTON

THE 539th meeting of the society was held in the Assembly Hall of the Cosmos Club, Saturday, April 3, 1915, called to order by President Bartsch at 8 P.M., with 65 persons present.

On recommendation of the council, Mr. Ben Miller was elected to active membership.

Under heading Brief Notes, Dr. L. O. Howard called attention to a wasps' nest he had lately seen which was marked by a conspicuous blue streak. In making this nest the wasps had evidently made the blue streaked part out of a blue building paper, instead of making their pulp from the natural wood. Messrs. Bartsch and Lyon referred to the red-headed woodpeckers in the grounds of Freedmen's Hospital, stating that a few birds had remained during the winter of 1914–15, though none had wintered during 1913–1914. The species is abundant in the hospital grounds this spring. Messrs. Bartsch and Bailey